The Glass Industry
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The Glass Division Meeting

Reviewed by Members of The Glass Industry Staff

AT the 35th Annual Meeting of the American Ceramic Society held at the Hotel William Penn, Pittsburgh, Pa., February 12-17, the series of Glass Division meetings aroused a great deal of interest among the members, many of whom felt that the program was one of the best ever presented to the Division. There was a good attendance and many interesting and informative discussions followed the presentation of the papers.

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J. C. Hostetter of the Corning Glass Works was elected President of the Society for the ensuing year, succeeding Emerson P. Poste, who held the office during the past year.

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Monday Afternoon Session of the Glass Division

Dr. Tillotson in the chair, with the moral support of Jack Waggoner.

The Chairman announced that some slight changes in the program would be needed. The luncheon on Tuesday at which F. C. Flint was scheduled to speak on the program on the joint meeting of the Industrial Division of the American Chemical Society, would be replaced by a joint meeting with the Art and White Wares Division, at which Dr. Avinoff of the Carnegie Museum was to have spoken. To make confusion worse confounded, Dr. Avinoff could not be present and a further substitution would be made. Mr. Flint would speak at the Wednesday showing of Paul Geer's pictures of the Woodmont meeting.

One of the earliest manufacturing establishments of colonial America was a glass factory at Jamestown, Va. The furnaces were now to be restored and at the present meeting some of the Jamestown wares would be exhibited.

The chairman appointed J. T. Littleton, G. W. Morey and F. C. Flint as a committee to nominate officers for the coming year.

A dictaphone stood before the Secretary and the Chairman read a typed harangue that had been placed in his hands calling on all members who wished to discuss papers to talk to the dictaphone. The typescript gave gruesome details of the way to hold the machine to the face, and Donald Sharp inquired whether this was a scheme of the local committee or of the Dictaphone Company, and added that the probable results would be to discourage discussion.

It was then moved, seconded, and carried unanimously that the dictaphone be not used; but by the time this had been done, no one remembered how the resolution was worded, and the Chairman ruled that members could please themselves whether they used the apparatus or not. With complete unanimity, the speakers ignored the contraption.

Paper No. 1. In the absence of Mr. Saunders, Dr. Tool read the paper (Effect of Heat Treatment on the Thermal Expansion of Glass). The glass on which the work, or most of it, was done, was of the Pyrex type. The sample was a ring cut from a tube, but smaller than those originally used by Peters. The true thermal expansion near the annealing range was easily disturbed by other effects. To get the true expansivity, the experiment must be conducted quickly, or a drift towards a different molecular packing occurred. This normally gave an additional expansion, but in some cases a more-slowly returning effect might afterwards cancel this additional expansion or even more than cancel. Dr. Tool suspected this might be of the nature of incipient devitrification.

If the glasses were held for a long time at 450° C, its linear expansion as measured at low temperatures was about 3.05×10^{-6} per degree C. If held for a while at 650° C, the expansivity rose to 3.4×10^{-6}. This is a 10% increase.

In reply to a question Dr. Tool said that the phenomena seemed somewhat anomalous: that one might very well have expected the expansivity to become less, rather than greater, by an increase of the working temperatures.

Paper No. 2. The relations between Density, Refraction, Dispersion, and Thermal Expansion of Soda-Silica and Soda-Calcia-Silica Glasses, with variations of the amounts of the several oxides.

This paper contains so much experimental material that it is difficult to summarize, and Dr. Finn was given a double allowance of time to present it. A number of papers were shown on the screen, indicating the Critical Temperature (the temperature at which the linear thermal expansion changed) and the Softening Temperature (the temperature at which the expansity had a maximum value). The relation of these to the properties of vitreous silica was mentioned several times.

Turning to the connection between specific volume (reciprocal of specific gravity) and refractivity, as shown on graphs, Dr. Finn reiterated his confidence in the reality of the breaks in the slope of the curves for straight soda-

silica glasses. These breaks occurred at Na_2O/SiO_2 ratios of 4/6, 3/6, and 2/6. It was hard to distinguish these breaks if index of refraction were plotted against density, but in Dr. Finn's opinion, the evidence was very definite where refraction was plotted against specific volume, that is reciprocal of density. [From the discussion later, it appears that not everyone is equally confident of this.]

The refractive index was measured for several wave lengths and light, in order to investigate the dispersion. The wave lengths used were not entirely the conventional ones used by opticians, being Lithium Red (6707 A. U.), Sodium Yellow (5893), Mercury Green (5461), and Mercury Blue (4358).

For the ordinary soda-silica and soda-lime glasses, N(index of refraction) plotted against $1/\lambda^2$ (where λ is wave length) gave substantially straight lines. But this was not true of the other glasses, such as those containing barium or lead.

In glasses containing 80% silica and 20% alkali, the alkali being either lithia, soda, or potash, it was found that the refractive index became 1.535, 1.4890, 1.4848; that is, the lighter molecules of alkali gave the greater refractive index. Dr. Finn proposed to try how Caesium and Rubidium Oxides behaved in this respect. [In the discussion F. W. Preston suggested that the phenomena was consistent with the supposition that vitreous silica was essentially a mass of loosely piled and chaotically arranged tetrahedra of SiO_4, and that lithium ions could pack into the interstices without swelling the "lattice," thus adding mass without adding volume, while potassium ions could not do this.]

Dr. Finn had tried melting Thallium glasses, and found as much as half the thallium distilled away in the course of three hours melting.

Dr. Littleton expressed disapproval of some of Dr. Finn's ways of defining points of arbitrary viscosity: he also referred to work of Dr. W. E. S. Turner which seemed to him to discount the possibility of treating ordinary glass as being based on a vitreous silica framework.

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At this stage it was announced that Professor Turner had hoped to be present at this meeting of the Society, and had sent word that he regretted its impossibility, but was now hoping to visit America in 1934.

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Paper No. 3. Observations on the Release of Strain in Glass. Mr. Bailey read the paper on behalf of himself and Mr. Sharp.

Mr. Bailey said that the work naturally followed in thought that of Adams and Williamson, but he invited attention to points of difference. Adams and Williamson used fairly large blocks of thermally strained glass. Bailey and Sharp used small specimens and strained them mechanically. Adams and Williamson allowed some considerable time to elapse before beginning observations, so the first part of their curve was always missing. Adams and Williamson were interested in precise annealing of optical glass: Bailey and Sharp in the commercial annealing of Fourcault window glass and the like.

The present authors were interested in two phenomena: (1) the rate of release of stress was too high in the initial stages to square with the "A and W" formula. (2) Repeat tests on the same specimen did not reproduce the same annealing curve: the glass released its stress less readily each time the test was repeated, even if six or more times.

Mr. Bailey referred to the observation of Filon and Harris on permanent residual birefringence, and was unable to get results, on repeating those experiments, that suggested the Filon phenomenon to be of any perceptible significance. He referred also to Dr. Lillie's observations on the change of rate-of-stretch with time, in viscosity measurements.

Bailey & Sharp in their original experiments used a central load on a little bressumer beam of glass. They had now changed to a "no-shear load" giving constant bending moment over the central parts of the span, and found it a great improvement.

A great number of diagrams were exhibited, and an empirical formula derived which seemed to satisfy the observations better than the "A and W" ones.

Finally some ingenious experiments on accelerating the rate of thermal annealing by mechanical flexing of the glass first one way and then the other, were described, and were received with much interest.

F. W. Preston expressed the opinion that W. H. Hampton's formulæ, being physically more attractive, and giving, for the cases examined, just as good straight lines as Mr. Bailey's, would be preferable even now, unless new evidence at present being sought experimentally by Dr. Morey proved adverse. Howard Lillie asked for an interpretation of the apparent change of viscosity with time, and after a brief reply by Mr. Bailey, it was agreed, at the suggestion of Dr. Littleton, to postpone this part of the debate until after a hearing of Dr. Lillie's own paper on Tuesday.

Paper No. 4. "Gases in Glass." The three previous papers were by men we have heard before, and Mr. Dalton is a welcome addition to our list of speakers. He explained his subject very adequately in a terse clear style that greatly commended itself.

On heating a sample of glass in a vacuum, a small amount of gas comes off at temperatures from 200 to 500° C. This is gas adsorbed on the surface of the specimen. At melting temperature (say 1400° C) a volume of gases is released amounting to a hundredfold the surface gases. Normally not less than 40 c.c. of gas (measured at NTP) are obtained from 100 grams of glass. The figure is often about double this.

Water vapor is usually a substantial item, 30 c.c. or more being frequent. If sodium nitrate is used in the batch, a good deal of oxygen is generally found in "degassing." Oxygen also comes from the reaction $2Fe_2O_3 \rightarrow 4\ FeO + O_2$ or some similar reaction, that is, some reduction in the ferric oxide towards a more ferrous condition of the iron. The presence of arsenic in the batch tends to give oxygen in the degassing process.

The function of arsenic in "plaining" a batch was, in Mr. Dalton's opinion, similar to that of ammonia in a glucose-water solution. If air be stirred into a glucose solution, plaining out may be slow. But if ammonia be present it forces its way into the air bubbles expanding

them and causing them to rise rapidly. The arsenic seems to remain in solution unless it reaches a gas interface, when it crosses the boundary readily and itself becomes a gas.

Borosilicate glasses seem to retain water more than ordinary glasses.

In tests of melts of various sizes, it was found that the larger the melt, the greater the quantity of water retained, in spite of a longer melting time. This was consistent with the assumption that water like arsenic, does not readily come out of solution except when it reaches an existing interface, and small melts have relatively a larger glass-air interface.

The CO_2 content of glasses seemed to be faintly constant, but the value obtained seemed to be too high to be an equilibrium value.

The paper was very well received and considerably debated, the subject being clearly of great practical interest to very many people.

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These four papers were all that were originally scheduled for the afternoon, but Dr. Scholes considered that the Physicists and Engineers had been providing a very heavy diet all afternoon, and decided to round off the meal with a slight "sweetmeat" of chemistry. His paper, not listed, dealt with the determination of alkali in glass.

Ordinarily, the other ingredients in a glass are determined quantitively and the alkalis are found "by difference." It follows that all errors in determining the other components pile up to be absorbed by the alkali estimation at the end, and there is no check on it at all unless the tedious J. Lawrence Smith method is used.

Dr. Scholes proposes a variant of the Berzelius method.

The glass, pulverized to 80 mesh, is digested with HF and H_2SO_4, the silica expelled, and the bases retained as sulphates, which are then taken up in water. Pure CaO is added, whereon the R_2O_3 group and the magnesia appear as hydrates, the residue being calcium sulphate and sodium sulphate.

Enough barium hydroxide is added to react with all the sulphates and then CO_2 is bubbled through the solution to carbonate all bases.

Boiling for five minutes throws down the calcium and barium carbonates and the solution contains only sodium carbonate (plus potassium carbonate if potash be present at all). The solution can now be titrated N/5 filtrated with bromophenol blue or methyl orange as indicator with N/5 acid, which gives a sharp end point.

Tuesday Morning Session

Paper No. 5. Maurice H. Bigelow opened with a history of ruby glasses in general. Apparently copper rubies were the first to be discovered and then the gold ones, selenium being the last. The gold rubies proved colloidal in nature, but the structure of selenium ones appeared to be grained on a somewhat coarser scale. The suggestion had been made that the color was due to a grain of cadmium sulphide and cadmium selenide in mutual solution.

The experimental furnace had a hearth area of about two square feet and equal masses of furnace-charge were used in all cases. A 30-hour cooling schedule was used.

A variety of base batches was tried, and it was found that a mixture of soda, zinc oxide and silica in 1 : 1 : 4 ratio was most convenient. A great variety of additions to this base glass was tried. Selenium, sulphur, antimony, arsenic, carbon, sodium nitrate, metallic aluminum, and so on, being combined in different proportions, one, two, or three of them at a time.

A reducing agent proved necessary, and metallic aluminum appeared to work as well as carbon. Arsenic or antimony was needed, and of these arsenic was much the more satisfactory. Aluminum will not act in the presence of antimony. Oxidizing agents such as sodium nitrate destroyed the color. Cadmium sulphide is essential. An increase of sulphur gives orange or brown colors. So far as these experiments were concerned, the selenium acted best when it amounted to from 1 to 2% of the batch weight.

X-ray analyses were made, satisfying the experimenters that the glass contained particles of a material whose lattice was consistent with the belief that it was a solid solution of cadmium sulphide and cadmium selenide. Tables of data were produced in support of the view.

X-ray analysis of colorless selenium glass proved impracticable, as the colorless glass developed a ruby tint on X-ray bombardment. It was further confirmed that cubic cadmium sulphide inverted to the hexagonal structure on heating.

Paper No. 6. A. K. Lyle presented the joint Lyle-Sharp paper on Color changes, in Flint Glasses, defining "flint" as bottle glass normally intended to be colorless. Milk bottles might be slightly pink or salmon colored, while table ware was frequently faintly blue or green. A long list of color changes brought about by a great variety of conditions was given and a number of specimens exhibited.

Ferrous oxide gives a green color with a lime batch, but blue with magnesia. Ferrosoferric oxide gives a neutral or gray color. For decolorizing, selenium, manganese, cobalt, nickel, or rare earths can be used, but the color-effects vary with the other (colorless) bases of the glass. The pink color of manganese can be neutralized by a re-lehring. The color of neodymium glasses is entirely different by daylight and electric light. The color of many oxides varies greatly with the thickness of the glass, in some cases the thick places show pink and the thin ones green.

High quantum radiations, X-rays or λ-rays, behave as if reducing: ultra-violet behaves like an oxidizing agency.

Paper No. 7. This paper by Frederick Brackett, caused a great deal of comment. It is different in scope from all other papers presented, and did not discuss glass problems as such, but the action of radiant energy of various wave lengths upon foodstuffs and organisms, a matter which is of importance at times when food is put up in glass containers.

In so far as light consists of quanta, the ultra-violet projectiles may be likened to steel-jacketted high velocity bullets, the visible spectrum quanta to slower ammunition, and the infra red to more or less innocuous popgun corks.

The size of the originating and receiving circuits also varied. The molecule was normally responsible for the infra red: visible radiation arose from electron-orbit changes within the atom, and the ultra-violet was apt to blow electrons clear out of the atom.

Ultra-violet light shorter than .30 mu. was commonly lethal in character. Blue violet light was the principal agency causing plants to turn toward the light. Yellow and red had little effect in this. Photosynthesis in plants on the other hand was activated by all visible radiations, though it begins to die out rapidly in the orange and red.

Graphs were shown of a number of glasses which cut off sharply wave lengths shorter than a variety of given points, transmitting freely below that.

The spectral curve of a mercury arc was compared with the destruction of colonies of algae subjected to the light of the spectrum in a very large spectograph made for the purpose.

The difference in transmitting power of samples of fresh and rancid oils (cotton-seed and corn oils) was shown, and it was explained how the spectophotometric curve rose, giving greater transmission, in certain regions, when the oil was rendered rancid by the impact of quanta of the appropriate energy.

In general, the destruction comes from light of wave lengths shorter than a certain threshold value, but this threshold varies with different organic substances.

E. L. Hettinger expressed the opinion, from the graphs exhibited, that apparently plants could make no effective use of the infra red. Mr. Brackett replied that probably the mere heating effect of the infra red would evaporate water from the leaves and so help draw up water from the roots and promote respiration.

L. T. Sherwood inquired about cod-liver oil, and Mr. Brackett replied that it was known to be very sensitive to photochemical change, but the details were not yet known.

Paper No. 8. Dr. Guyers' paper began with outlining the difficulties that had existed till recently in measuring currents of the order 10^{-13} or 10^{-16} amperes. Electrometers were unsatisfactory, but the invention of the triode valve offered possibilities free from instability. The advantage had remained theoretical, owing to the disturbing effects of changes on the glass wall of the vacuum tube, but these had largely been overcome in the new G. E. Pilotron. A sensitivity of 10^{-18} amp. was attainable with two tubes in a balanced bridge circuit, and 10^{-13} amp. was measurable with an accuracy of 1%.

Great care in shielding of course remains necessary.

The form of test specimens was examined and explained, and graphs showing the way the charging current behaved on throwing the switch (on, or off or to other potentials) were shown. The difference between chilled and annealed glass was demonstrated. Mechanical stresses produced little or no effect, other than a thermodynamic effect due to the slight temperature changes arising from the adiabatic expansion or contraction of the glass (and this affected the current only some 3%).

Very frequently the charging current does not alter a steady value for minutes or hours, and the past electrical history of the specimen is significant.

Paper No. 9. The joint paper of Dr. Lillie and Dr. Morey was presented by Morey. Dr. Morey began by commenting on the use of the term "liquid" or "under cooled liquid" as applied to glass. Scientific men were apt to take familiar words and use them in a special meaning, and expect other people to understand promptly the significance of the new use of the term. Thus glass may be described perfectly logically as an under cooled liquid by a physical chemist who is interested in the phase-equilibrium diagram, but he simply means by that that the glass is below its crystallizing temperature. He does not mean it to imply that the glass necessarily possesses any other characteristics, whatever, of a liquid.

So far as Dr. Morey himself is concerned, he does not mean anything more by "under cooled liquid" than what is stated in the foregoing sentence, nor does he wish to draw any distinction between the "liquid" and the "glassy" state or lay any special stress upon the existence of definite "transformation points." Among the things he calls attention to is the fact that some glasses at least, can be crysllized (devitrified) well below their annealing point.

An experiment has been running since December 3, 1931 at the Geophysical Laboratory on the rate of release of stress with time, in a block of Pyrex held at a very low temperature and a very constant temperature. If S be the optical strain (birefringence) a plot of 1/S against time should give a straight line. It is found that it does so after the first few weeks, but in these first few weeks the rate of release of strain is much more rapid.

There is no apparent evidence that a limiting stress will be reached beyond which there will be no further annealing. The experiments are continuing, and beyond presenting experimental data, Dr. Morey did not wish to theorize on interpretations. In response to a question, however, he indicated that if we tried to make the evidence fit the Adams and Williamson law, by assuming that the glass acquired a greater viscosity as its structure tightened up in the annealing, then the increase of viscosity would have to be, in all probability, ten or a hundred fold, and nearer the latter than the former.

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The listed business for the morning being now concluded and a little time remaining over the Chairman invited unlisted business. Dr. Finn stated that the Patent Office had called him up and asked for a definition of "Borosilicate Glass," and he would like the opinion of the Division on the point. Dr. Sharp asked what difference it made anyway, and F. W. Preston asked for a definition of "Glass" without bothering with Borosilicate. The meeting apparently felt unable to help the Patent Office out.

Dr. Walter Sparks had a collection of beads and broken vessels of glass from the Jamestown, Virginia, factory of nearly three hundred years ago. The glass factory was located recently and some remnants of the old industry retrieved. Of these he now exhibited a number.

At the midday luncheon a joint luncheon of the divisions, Dr. Kostellow of Carnegie Tech lectured on his concept of Art. The lecture met with a mixed reception, some members being gratified on being told that machines could, under proper conditions, produce artistic wares, and others holding that the lecture contained no ideas that were new or other than self-evident. The little streaks of humor, however, were universally enjoyed.

On Tuesday at noon at the luncheon of the Glass Division Francis C. Flint spoke on the "Plans for the Symposium on Glass."

Tuesday Afternoon Session

Paper No. 10. The "strain point" is an arbitrarily defined temperature or viscosity value, below which new permanent strains are not introduced by rapid cooling. It happens to be convenient in a plant making numerous glasses to have the temperatures at which various glasses will have a particular viscosity, so that the annealing schedules can be laid out easily and confidently.

The strain point is, practically speaking, the lowest temperature at which viscosity can be measured by mechanical means.

Lillie has modified the Corning fibre apparatus slightly, keeping the whole of the fibre inside the furnace and extending beyond the furnace only lengths of drill rod. The automatic temperature control holds the specimen throughout its length and throughout the duration of the test, very uniformly. (1° C or less).

The specimen elongates relatively rapidly at first, and then approaches a steady rate of extension. The viscosity computed for this steady state (which needs as a rule many hours to attain) is much higher than is found if measurements are taken early in the experiment. Accordingly that part of the log (viscosity) versus temperature curve (which was given in 1931) that relates to low temperatures needs some correction. In the preferable plot of log viscosity against reciprocal of absolute temperature, the curve benefits decidely in smoothness and uniformity of sweep by the change. The evidence is that, regarding glass as an associated liquid, the degree of association increases continuously with declining temperature.

Paper No. 11. This paper was presented by Dr. Morey on behalf of his colleagues. The system in question was, in general, of more interest to the iron-metallurgist than to the glass man proper, but was a very interesting system from a scientific point of view.

True glasses were rarely obtained, quenching being insufficient to prevent the formation of fine grained or feathery crystals.

The iron was not all in the ferrous state, but some Fe_2O_3 was always present. If an attempt were made to eliminate the ferric oxide entirely, the equilibrium $Fe : FeO : Fe_2O_3$ intervened and some metallic iron was formed.

In the system $CaO\text{-}FeO\text{-}SiO_2$ no ternary eutectics were found, but there were extensive areas of solid solution. (ferro-calcian olivines).

The story cannot conveniently be told here in the absence of diagrams.

Paper No. 12. This also was presented by Dr. Morey.

Work had been under way by Dr. Schairer for some years, but progress had been slow, as only forty platinum crucibles were available, owing to the depression.

A packed house listened to the paper, but here again we cannot detail the results in the absence of the diagrams. The silica-alumina side of the diagram representing high liquidus temperatures, was not well represented, but mullite near the boundary of its field had been crystallized at comparatively low temperatures considerably below glass melting heat, from melts containing, of course, almost as much soda as alumina.

Albite had at last been crystallized without hydrothermal appliances. It crystallized readily enough at 10° C below the liquidus, but could not be obtained at 50° C below. However it could not be crystallized from melts of a pure albite composition.

Paper No. 13. By Donald W. Ross. Some considerations concerning tank blocks, and the application of these in the study of metal line attack.

Paper No. 14. At this point the Reports of Committees were called for by the program.

Paper No. 15. By J. T. Littleton, Corning Glass Works. The Connection Between Conductivity and Viscosity in Glass Melts.

Dr. Littleton described a method of measuring the electrical conductivity of glass, wherein the glass was contained in a platinum crucible which acted as one electrode. The thermocouple formed the other electrode. Measurements were made from the strain point to about 1400° C. Results were given for four different glasses, a lime glass, a lead glass, a borosilicate and a lead borosilicate.

Viscosity of the lime glass was approximately proportional to the 4th power of the electrical resistance of the glass. Borosilicate glass had a higher resistance in proportion to viscosity than lead glass.

In view of the fact that electrical resistance probably depends on the resistance to motion of ions it seemed likely that electrical conductivity measurements might actually be a better means than viscosity measurements for working out crystallization and similar data.

It was interesting to note that extrapolation of electrical conductivity data indicates that the viscosity of glass at room temperatures would be about 10 to the 64th power.

Paper No. 16. By R. W. Goranson and L. H. Adams, Geophysical Laboratory. Presented by Dr. G. W. Morey. A Method for the Precise Measurement of Birefringence, Especially in Strained Glass.

The apparatus described by Dr. Morey who presented this paper in the absence of Dr. Goranson and Adams consisted of a device in which eliptically polarized light was passed through a quarter wave plate so that it could be resolved into plane polarized light, the measurement being made by the phase lag as determined by rotation of the analyzer. An accuracy of 0.05 millimicrons was claimed, which means that this new instrument will be a powerful aid in work on release of strain in glass. The sensitivity of the instrument may be appreciated by the fact that temperature variations in a glass specimen may be detected that cannot be found with a thermocouple.

Wednesday Morning Session

Paper No. 17. Glass as a Structural and Stress Resistance Material. By Frank W. Preston.

Paper No. 18. By F. C. Flint and A. K. Lyle. A Test on Chemical Resistance of Glass Containers.

Until comparatively recent years the use of glass con-

(*Continued on page 34*)

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The Glass Division Papers at the American Ceramic Society Meeting

THE Glass Division program at Pittsburgh was a full one, papers being plentiful, and their quality being undoubtedly the high water mark yet achieved at any of the Annual meetings. At times the Blue Room was packed to capacity, and only standing room was available.

It was the general opinion that the assembling of so much excellent matter should be credited in the first instance to Mr. Blau, the program chairman, who spent more effort than a little in assuring the adequacy of the program.

It is our understanding that the discovery of Mr. Brackett was due, to begin with, to Mr. Flint, who is to be congratulated on it. And our thanks are due also to A. Q. Tool, who made a special trip in order to present the opening paper of the sessions, at a time when he could not well be spared from home.

There drifted through the papers a spirit of promise that one day Glass Technology would be scientific, a coherent body of knowledge. It remains yet essentially an incoherent and empirical body of miscellaneous information, in which very little can be prognosticated, but everything must be investigated separately. For instance, a knowledge of one equilibrium diagram of a three component system, say soda-lime-silica, is no guide to the system potash-lime-silica or to the system first published at the meeting, soda-alumina-silica. Nor do the additive "factors" for refractive index or density of components mean much when applied to radically different glasses from those in which the "factors" were determined in the first instance.

But through the papers this year there ran a better promise; the opening paper by Tool showing the drift of thermal expansion with changing constitution was followed in the third paper by Bailey's demonstration of a drift in apparent (optical) viscosity, which was amplified and extended in paper 9, wherein Lillie and Morey measured the same phenomenon, or a variety of it, with great precision; Lillie also showed the drift of purely mechanical viscosity in an unmistakable manner in Paper 10. Guyer in Paper 8 demonstrated the existence of a similar phenomenon in connection with electrical conductivity at room temperatures. This evidence of the maturing of the glass under thermal, electrical, and mechanical treatments to a condition evidently appropriate to the temperature and other impressed conditions, must surely in the end lead to a clearer concept of the physical constitution of glass. Littleton's estimate in Paper 15 of the room temperature viscosity from electrical considerations, coming out a good deal higher than the earlier Corning estimates, and approximating Preston's estimate from optical considerations, may also point to a time when the various properties of glass may all be expressible in terms of one another or in terms of a fundamental constitution concept.

The gaps were not bridged at the meeting, but there is some hope that the chasms between the various properties of glass may in the not distant future, be bridged.

Correspondence

THE EDITOR,
THE GLASS INDUSTRY,
DEAR SIR,

THE INFLUENCE OF AMMONIUM SULPHATE ON THE AMOUNT OF SELENIUM NEEDED FOR DECLORISING PURPOSES

My natural interest in all that appears in your attractive Journal led me to read with pleasure the article by Mr. F. W. Noel in the January issue as soon as it reached me. I feel sure that Mr. Noel will only be too glad if I mention that our experience in regard to the influence of ammonium sulphate on the quantity of selenium required for decolorising purposes is rather different from his own.

He mentions that "ammonium sulphate also reduces the quantity of selenium required to decolorise the melt." In making this statement the author was referring to a comparison of batches containing a small amount of sodium sulphate on the one hand, and of ammonium sulphate on the other. As glass batches are melted by some manufacturers from time to time without the presence of either of these sulphates, comment may usefully be made on both cases; but I might say that in any case our experience is that the addition of ammonium sulphate in amount sufficient to be effective in melting and refining renders it necessary under normal conditions to use more and not less selenium.

Little difficulty appears to arise in decolorising with the normal amount of selenium glasses made from soda ash batches (with no sodium sulphate present) to which ammonium sulphate has been added to an extent not exceeding 5 parts per 1000 of sand. Large scale tests also appear to have confirmed the fact that no serious difficulty is found in decolorising such a batch with the normal amount of selenium. When the amount of added ammonium sulphate, however, reaches 7.5 parts per 1000 of sand, the normal amount of selenium is quite definitely found to be inadequate to produce colorless glass.

It is not difficult to understand why this should be the case. Ammonium sulphate acts as an accelerator in the melting and refining of glass rather differently from, say sodium nitrate or borax. These two latter materials fuse readily and thus assist in glazing the batch piles. When once selenium has passed into solution it is less easy to expel it; this is equally true of a number of volatile materials. Ammonium sulphate is, however, a volatile material and tends to keep the batch thoroughly open. This being so, loss of selenium by volatilisation is to be anticipated.

I may add that this loss of selenium can to some extent at least be reduced by employing selenite instead of the element selenium itself.

The case to which I have referred above is that of glass batches in which the source of alkali is soda ash only. We find that the same fact holds good even if 5 to 10 parts of sodium sulphate are present in the batch.

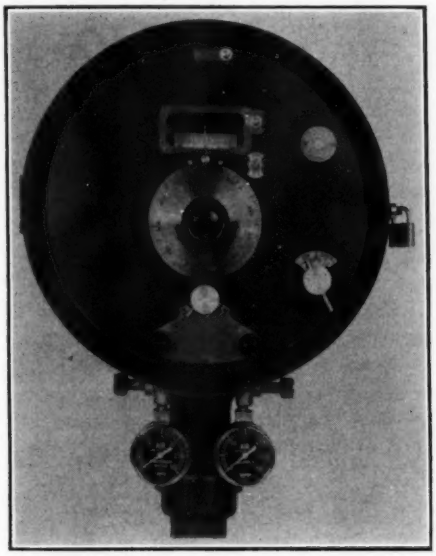
Yours faithfully,

2ND FEBRUARY, 1933 W. E. S. TURNER.

Latest Development in Temperature Control Equipment

The Potentiometer Stabilog—an instrument combining the many features and advantages of Stabilog Control and Potentiometer temperature measurement—is the latest addition to the complete line of control equipment manufactured by the Foxboro Company of Foxboro, Mass.

Through the development of this instrument, the 100% automatic control provided by the Stabilog System is made available for temperatures up to 2800° F. (1500° C.). In addition, the long-distance feature of the Potentiometer measuring system makes the instrument particularly valuable where there is a great distance or height between the point of measurement and the controller. Where it is desirable to use this instrument on the lower temperature ranges, the



Wheatstone Bridge and resistance bulb measuring system is used.

The Potentiometer Stabilog is a non-recording instrument but it is so constructed that a record of its operation may be made on a Foxboro Recording Potentiometer Pyrometer using the same thermocouple. One multiple-point Recorder may be hooked up with as many as six Potentiometer Stabilogs thus recording and controlling from the same thermocouples.

A preliminary description of this instrument has been prepared by the Foxboro Company, for distribution to interested readers.

Plate Glass Production Increasing

The total production of polished plate glass by the member companies of the Plate Glass manufacturers of Amercia, as reported by Secretary P. A. Hughes for the month of January, 1933, was 6,188,263 sq. ft., as compared to 4,267,809 sq. ft. produced by the same companies in the preceding month, December, 1932, and 5,499,611 sq. ft. produced by the Association members in the corresponding month last year, January, 1932.

The total production of polished plate glass in the United States for the year 1932 was 52,221,635 sq. ft. (all plants).

The Glass Division Meeting

(*Continued from page* 31)

tainers was limited to food products, beverages and drinking water. Certain other articles were shipped in large containers and bottled shortly before use. As a result the contents of a bottle were seldom in contact with the glass for a sufficiently long period of time to develop a detrimental reaction with the container.

In recent years, however, it has become customary to pack an ever increasing variety of chemicals and foods at the factory. The container often undergoes a prolonged period of storage before it is finally opened and its contents used by the ultimate consumer. Because of this it has become necessary to develop bottle compositions which are especially resistant to deterioration.

Further, there is a growing tendency on the part of consumers to specify certain qualities of resistance which must be met by the manufacturers. Unfortunately for all concerned, there is no test which truly represents the resistance of the glass to attack and which can be performed in a short period of time.

A resumé of possible tests was given. It was also pointed out that the range of commercial glass container compositions is very small.

The conclusion was reached that a digestion in an autoclave was the best commercial test at present available. The recommended procedure was as follows:

A standard type of bottle is always used. This bottle is filled to a certain height with distilled water and placed in the autoclave. It is held for six hours under steam pressure of thirty-five pounds per square inch. At the end of this period the contents of the bottle is titrated with HCl solution using methyl red as an indicator. The titration of common glass is usually .10 to .11 gms. NaOH per liter. When a consumer wishes a more resistant glass the amount of NaOH obtained on this test may be specified to correspond with the quality required.

This test furnishes a basis whereby the manufacturer and consumer may reach a definite understanding. As to the requirements it may be completed in one working day, and requires relatively simple apparatus. Results are also readily duplicated in different laboratories.

This method has been used as a control test for a number of years by the Hazel-Atlas Company.

Paper No. 19. By A. B. Oday and H. H. Blau. Recent Process in Cooperative Studies of Illuminating Glasses.

Much confusion has existed because of the difference in names used by the scientists, the illuminating engineer and the glassworker. The committee has done much to simplify and define the nomenclature so that misunderstanding and ambiguity are avoided.

Particularly in the field of diffusion glasses much difficulty has been experienced since opal, alabaster, frosted, glue-chipped and prismatic glasses are all diffusion glasses in the physical sense.

Data taken on light distribution around a shaded lamp may be recorded in several ways, some of which are not understood by many people.

Since the motivating idea is to coordinate the work of all those engaged in manufacture, use, and application of the illuminating glassware, the committee has confined its efforts largely to the definition of terms, the standardization tests thus making this data available to all interested parties.

Paper No. 20. By J. C. Hostetter. Notes on the Classification of Diffusing Glasses.

The classification of glasses for illuminating glassware is very difficult due to the overlapping of the various kinds of glass. For instance, alabaster and opal glasses are diffusing glasses which spread the light because of minute particles contained within themselves. Frosted glass whether acid etched or sand blasted accomplishes the same purpose. Glue chipped, rough surfaced and prismatic surface glass also diffuse the light. All these are diffusing glasses in the physical sense.

Further classification showed that the field of illuminating glassware is so broad that in the form of chimneys, reflectors, lenses, globes, etc., it may include glasses of almost any composition.

Paper No. 21. By Robert Miller and Walter Sturrock. The Calculation of Limiting Sizes of Flat Glass.

Glass has many advantages as a decorative material in buildings. In recent years there has been a marked increase in the use of polished plate for wall surfaces, column faces and the like.

The modern indirect lighting panels have made relatively large glass surfaces a necessity and more recently the glass ceiling with light above has come into vogue. All of these uses have made necessary the use of plate glass in places where the glass was subjected to certain stresses.

A study of the limiting strength of sheet glass subjected to pressure on one flat side was made. Owing to the scratches and surface injuries a safety factor of ten was recommended where glass was to be used in a horizontal position or where it might be injured.

The results of tests indicated that the following formula gave safe results.

$$P = \frac{21000T^2}{AF}$$

where T is the thickness in inches, A is the area in square inches and P is the load in pounds per square inch.

The limited sizes obtained by this formula are single strength, seven square feet; $\frac{3}{16}$ of inch, 29 square feet; ¼ of inch, 39 square feet; ⅜ of inch, 60 square feet; ½ inch, 80 square feet.

Certain of the opal glasses were found to be slightly stronger than clear glass. Wire glass and frosted or decorated glasses were weaker than clear plate.

Strains due to temperature differences between the outside surface and the inside surface may be reduced by the use of two glass plates separated by an air space. It was found that the best spacing was from ¾ inch to 1¼ inches. Double glass very greatly reduces the heat loss through windows.

Where lights are hidden back of a glass panel it was found that two diffusing plates separated by an air space gave a much pleasanter and softer light than one plate, and in addition two plates protected the wall panel from the heat.

Sand and Air

By MILAN TEN EYCK

NOT so many years ago the decoration of wood, glass and other materials by sandblast was unthought of. Making a business of this craft would have been considered foolish. Sandblast was only used for cleaning purposes. Today's decorative trends in architecture and interior embellishment of homes, theatres, stores and other buildings make the business of sandblasting a profitable enterprise. Little has been told about it. The few people who are familiar with the more complicated processes of the art are inclined to be somewhat secretive. The same condition prevailed when the writer decided to make sandblasting his business five years ago. A fairly successful career makes him feel qualified to pass along what he has learned by experiment and observation during that time. The field is large enough. There is room for several more.

Our shop produced designed sandblasted work on glass, wood, tile, marble, metal; practically all other materials that are available for general building or decorative purposes. Antique and weather-worn effects on wood and old and new furniture was an extremely profitable source of income. We also employed this versatile medium to remove paint from automobiles, to clean castings and corroded machinery parts and to remove paint from certain types of buildings.

THE AIR COMPRESSOR

In the beginning, after the writer had assimilated the few theories and meagre information available about sandblasting, the next step was to get into actual operation. We knew that we should need an air compressor, a motor to run it, a place to put the air and some machinery to do the actual sandblasting. A thorough study of the market convinced us that because of unfamiliarity with machinery it would be wiser to purchase nothing but new equipment. Probably we could have saved considerable by buying used material, but the fact that we had no trouble with any of it during five years of constant use assures us that my first decision was the best.

We bought a two-cylinder, vertical type air compressor of a good make that was built to deliver a maximum pressure of 125 pounds of air at the rate of 119 cubic feet a minute. A 25 horsepower motor ran the compressor. The compressor was equipped with an automatic unloader—well worth its slight extra cost because of the power it saved. The compressor pumped air to a pressure of 110 pounds; the unloader automatically shut off the compressor, while the motor idled, until the air pressure dropped to 90 pounds. The lowered pressure then released a valve in the unloader, and the compressor would take the pressure back up to 110 pounds. These unloaders are adjustable and can be set to any desired on and off pressures desired.

The air was pumped into a receiving tank, two feet in diameter, six feet in height. From there it was delivered to the sandblast tank.

Between the compressor and air receiver we had an after-cooler installed. This device lowered the temperature of the air before it entered the receiver. The lowering of temperature was accomplished by a combination of running water and air baffle plates. The idea back of the after-cooler is logical enough. One of the greatest hindrances to sandblasting is the collection of moisture in the air which tends to produce damp sand and water at the business end of the equipment—a trouble that can be readily understood. Moisture naturally collects in the air receiver, because the air which is compressed as it comes through the compressor on its way to the receiver naturally expands as it enters

CUTTING THE "RUBBER." THE DESIGN IS TRANSFERRED FROM PAPER TO RUBBER AND CUT BY HAND

the larger area. The after-cooler, together with a short hook-up of a two-inch pipe-line between the compressor and the receiver, a distance of less than six feet, enabled us to control the output of moisture to the receiver. From the air receiver a two-inch pipe-line carried the air twenty-five feet into the sandblast room. This line was run with but two bends or joints in its total length. We found that the fewer joints in the air-lines, the lower was the loss of air. Straight lines helped to cut down on moisture too. In order to once more eliminate the moisture hazard, we had installed at the end of the air line, right next to the sandblast machine, an air separator that was nicknamed "The Spitter." The Spitter was so called because it continually and automatically removed the surplus water in the line between the receiver and the sandblast by a water-trap that removed it in little "spits"—and continued to do so long after we had quit for the day. We never did figure out the workings of the Spitter, but it was a very economical addition to our equipment. It was added five days after operations were started—five days in which the sandblaster was continually drenched by a small stream of water and was handicapped by wet sand that clogged the sandblast machine. With these precautions taken against our enemy, Water, the operators could sandblast on the rainiest days with no fear of damp sand or water in the lines.

THE SANDBLASTING EQUIPMENT

The sandblast machine, one of the newest and best types available, had a capacity of about 600 pounds of sand. It was also equipped with a moisture separator that no doubt helped to keep water out of the sand. For speedy work, this pressure type machine was the most economical; but as it required a nozzle of not less than one-quarter inch in diameter at the nozzle opening before it would operate efficiently, it would not produce fine work. Later an induction, or suction type of sandblast was added. High pressure could not be used with this machine—it developed about forty pounds pressure at the nozzle, with 110 pounds in the receiver; but this speed handicap was offset by the fine work turned out on glass. Equipped with a 1/16 inch or 1/32 inch nozzle, the operator could control the flow of sand so nicely that he could produce finely etched and carved glass without the aid of a stencil or plastic covering on the glass.

The air pressure of the larger equipment was regulated at the tank. The smaller, induction tank, had a fixed con-

THE SANDBLASTER AT WORK

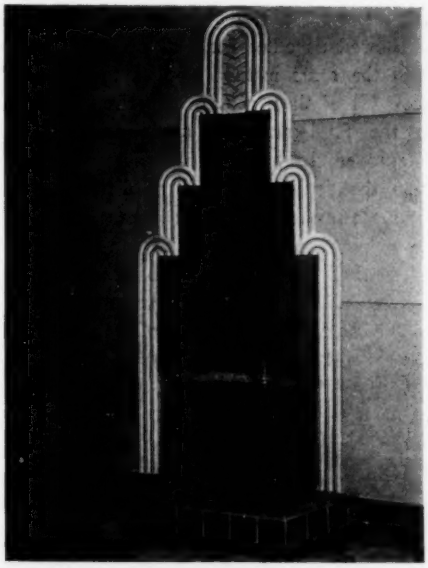
trol of air. Instead of the hose and nozzle of the larger, this induction system used a gun, similar in looks and action to a spray-paint gun with interchangeable cast-iron nozzles. The air and sand flow was regulated and controlled at the gun by a trigger. As we progressed, these cast-iron nozzles were replaced by special nozzles. The cast-iron type were interchangeable and had to be replaced several times a day; the new type was more permanent. These nozzles lasted for many hundreds of hours of actual use and retained their original hole diameter—an essential in efficient sandblasting. They more than paid for their extra cost.

After consultations with a number of engineers, experts and conversationalists, from whom the writer learned very little, he laid out the sandblast room himself. A carpenter, some wall-board, nails and tools built it very cheaply. Fifteen feet long, ten feet wide, ten feet high, it was large enough for all of the work except that of removing paint from automobiles. Two operators could work in it comfortably, side by side. The walls and ceiling were built of ordinary plasterboard sealed at the joints to make it air and dust tight. As it was built in one corner of the shop, but two walls were needed—the other two being the brick walls of the building. Two windows provided enough daylight and eight one hundred watt bulbs in a glassed-in frame served for night work. A door, six feet wide and eight and one half feet high was provided in the ten foot side. It was large enough to permit the entrance of wheeled racks, built as ordinary glass racks; and allowed large plates of glass to be handled from start to finish without being removed from the racks. This room, although much lower in cost than the expensive steel-walled sandblast rooms that can be had, answered all purposes and showed no appreciable signs of wear after five years of use. To overcome the abrasive action of sand on the plasterboard, the walls and ceiling were covered with an application of glue, glycerine and water that will be described later. This compound was renewed occasionally, but at all times it resisted the wear and tear of the sandblast.

Dust removal was a problem, particularly because of the expensive installations offered by various agents. But a careful study of methods and a little common-sense thinking enabled the writer to devise a system of dust removal which, exclusive of the blower and motor, cost less than one hundred dollars.

The sandblast room contained, roughly, 1,500 cubic feet. The exhauster or blower used could handle 1,200 cubic feet of air a minute. Therefore openings were made in the front wall of the sandblast room large enough to permit the passage of approximately 1,000 cubic feet of air per minute, to avoid any undue buckling of the walls and ceiling. The end wall of the room was built double—that is, an inner and outer wall with an air space in between. This was done so that the intake holes cut in this wall would be staggered. On the outer wall the holes were five feet from the floor, on the inner wall they were six feet from the floor. This did away with a direct passage of air and seemed to cause a better circulation, or suction. Twelve holes were cut in the ceiling of this room at the opposite end from the door, to admit twelve funnels. The total cubic inch capacity of these openings exceeded the total at outlets. The writer figured that this system would prevent clogging of dust at the ceiling outlets. There are, no doubt, more efficient, more scientific systems than this, but it worked. These funnels were connected to ordinary galvanized iron four inch water spouting. Each funnel or vent ran into a square box. The box was connected to the blower where the exhaust was carried out of the building by a 24 inch galvanized iron pipe. The exhaust or dust tank was made of heavy gauge galvanized iron, six feet long, three feet wide, three feet high. The exhaust line ended in the top of the tank, six inches lower than the top itself. The entire tank was soldered and sealed against air and water leakage. It was kept about two-thirds full of water. A sliding door was provided to enable the tank to be cleaned of the accumulated muck, or fine dust and water. The idea was that the water would absorb most of the dust. To keep the tank from bursting, an air outlet was built of thirty-six inch diameter pipe, to offset the possibility of back-pressure in the twenty-four inch pipe-line. It was also hoped that the larger vent would help to cut down the

force of the air as it was expelled from the tank, and allow what air and dust remained after the water bath to drop to the ground right near the tank. The outlet was three feet higher than the top of the tank, provided with a conical inverted hood to force the direction of the exhaust downwards. The whole system worked perfectly; and though the water in the tank did not completely absorb the dust, a person standing a few feet away from the end of the tank could notice no dust. On a few occasions when two men were sandblasting some material that kicked up a lot



THEATRE DRINKING FOUNTAIN OF BLACK GLASS, SANDBLASTED WITH FINE-PROCESS WORK

of dust, the tank would not absorb it fast enough and dust was observed coming through the tank exhaust in heavy clouds. This was overcome by the insertion of a garden hose under the hood, into the top of the outlet. The fine spray of water made the excess dust so heavy that it dropped at once. The tank never got too full of water. Evaporation took care of that. It required cleaning once a month. A five-horsepower motor was added for the dust removal system and worked independently of the sandblast equipment.

For cleaning automobiles, a wooden floor was built against the rear wall of the shop, outdoors. Three canvas walls or curtains that could be rolled up at will and a canvas roof provided the place for that operation. The canvas walls and roof kept the dust from spreading and a permanent, gentle breeze from the north enabled the operators to keep the south wall open most of the time giving them plenty of air circulation and light.

The sandblast operators were protected by metal and canvas helmets. Individual air lines from the main supply gave them fresh air at all times. They also wore respirators. Removable flat glass eyepieces proved best for visibility. Ordinary window glass was used and changed often because of the action of the sand on the glass. Heavy canvas and leather gloves and stout canvas overalls completed their costumes.

Several grades and sizes of sand were used. Silica sand, sixty to eighty mesh, was found best for average glass work. Steel shot was sometimes used for cleaning castings, etc., but sand was preferred. For fine work the eighty mesh sand was broken down to the size and feel of talc. The residue from the exhaust tank, properly dried, made a very good cutting medium for the finer work. Silica sand was found the best because of its sharp, edge-retaining quality and could be used over and over. The sand was allowed to accumulate on the floor of the sandblast room, and daily returned to a gravity grader, made by fastening four pieces of copper screens of various mesh, to a slanting base. The sand was thrown into the hopper of the grader by a boy each night, which took about thirty minutes.

The sand ran out of the hopper onto the screens. The finest mesh screen was at the top, the coarsest at the bottom. Automatically grading itself, the sand ran into bins. Each bin was kept covered and the proper grade used as required. Beach sand was good enough for cleaning cars and was cheaper because so little of it could be reclaimed. The more expensive silica sand was not a big item of cost, however. So much of it was used over and over. It disappeared at the rate of less than one-half ton a month.

When the sand got wet, or when rainy weather filled it with moisture, it was heated to remove the dampness. Spread in large shallow pans to a thickness of one inch it dried quickly with the aid of two hot-plate gas burners.

MISCELLANEOUS MATERIALS AND OPERATIONS

In preparing the various materials for designed sandblast, a number of mediums were used. For high class work on plate glass, wood and metal, a plastic material called "rubber" was heated and applied to the surface. Rubber, metal and sometimes wood stencils were used for quantity work on designed materials. As the plastics must be applied at about ninety degrees Fahrenheit, a double boiler was built with eight openings in its top large enough to receive sixteen-quart galvanized iron pails to about half their height. A drain-cock was provided to drain off the water, as it was found that the "rubber" spilled into the boiler and corroded the bottom. It was necessary to drain and clean this boiler once a week. A base of gas pipe and a single hot-plate gas burner completed the boiler.

Before applying the "rubber" the glass was warmed, in cold weather, just enough to remove the chill; then the surface was cleaned thoroughly. The "rubber" was applied with a brush; one thin coat that was allowed to dry, or cure, for a few hours, then a slightly heavier coat. The glass was always coated in the late afternoon or evening, allowed to cure over night and then it would be ready for design cutting the following day. As the compounds used for this purpose are made with a glue base, they naturally absorb a certain amount of moisture from the air. This difficulty was overcome by building a room in which the prepared glass was placed for curing. The temperature and humidity of the room was kept as nearly constant as possible. Metal, tile and all other materials except wood were treated in the same way. In preparing wood for fine design work, it was first treated with a heavy coat of shellac

and powdered silica; then the "rubber" was applied as related above.

Experiment, wasted time and lost temper proved that a few of the better known glue manufacturers make a resist or compound that is far superior to any home-made formula. For those who wish to try, ten parts of good hide glue, properly soaked, to one or two parts of glycerine, to which is added enough water to give the proper consistency, usually about twenty-five per cent in volume, (conditions cause this to vary; but the consistency should be similar to that of thin paste when the compound is heated,) will start you on your troubles. Add a few drops of formaldehyde to keep the glue from spoiling. If you have any knowledge of chemistry no doubt you can do better than the writer who had none. The above formula was the material used for the wall coating in the sandblast room. There, where it remained permanently, it resisted the sand-wear effectively.

The best type of manufactured compound to use is grayish white in color and comes in oiled paper-wrapped cakes weighing about ten pounds each.

The services of a good designer was obtained. It was a good investment. Original designs and no repetitions helped to establish the concern, especially with the architects and builders.

Although sandblasting on glass can be carried to several depths or processes, most of our designs could be executed in two-process work as effectively as four or more processes. That is, an ordinary surface sandblast, or frosting, and an interlapping second process of not more than 1/16 inch in depth.

All designs were perforated, then pounced onto the coated side of the glass. Then the design was cut in its entirety, preparatory to the sandblast. Where more than one process was used, all were cut at the same time; but only the "rubber" from the deepest cut was removed. Then it was sandblasted to about one-half of the desired depth. When the next cut was removed for a lighter sandblast, the first or deeper would attain its required depth at the same time because of its exposure to the second sandblast. In the case of four or more depths the same process was repeated. The "rubber" from the deepest cut was always removed first and never sandblasted deeper than the number of processes involved. That is, in four-process sandblasting, the deepest cut was first sandblasted to one fourth of its final depth; the next cut to about one third; the next to about one half and the final, or surface cut, would finish the operation. Originally the glass was removed from the sandblast room for each cut in the "rubber"; but this involved the laying on of the pattern each time, was inaccurate and proved too tedious. All of the cuts being made at the same time allowed the operator in the sandblast room to remove the "rubber" from each cut as it was required. He used the pattern as a guide.

The cutting was done with a stencil knife. There are several good makes. The best type is the one that looks like a lead pencil, with a blade running through its center. Several metal knives of this same style, with removable blades, can be had.

There is an art in cutting the "rubber" that can only be acquired through practice. The knife should be held perpendicularly in the hand and the lines of the design followed firmly—very much as an artist would use a pencil or crayon except for the position of the knife in the hand. Care should be taken that the knife does not slant in going around curves. This will result in undercutting or overcutting of the "rubber." Then the thin places will burn away during the sandblast, leaving rough, ragged lines.

In sandblasting it was found that an even motion, similar to that used by a spray painter, back and forth across the surface of the glass, regardless of where the design was, produced the most effective results in the quickest time. Practice showed us other ways of producing varied effects. Practically the same method applies to sandblasting other materials. All of them require experiment.

When the final cut was made and sandblasted, the operator sprayed the piece with air, removing all dust and sand from the "rubber." Full of dirt, the "rubber" deteriorates more rapidly than if it is kept clean. Sometimes, in dry weather, the action of the sandblast hardened the "rubber" so that it was difficult to remove from the glass. This was remedied by the application of cloths, wet and wrung out almost dry. The damp cloths were left on the glass until the "rubber" had absorbed the moisture and the cloths were bone-dry. Then the "rubber" could be easily removed, replaced in the buckets in the steam boiler and melted to be used over again. With reasonable care as to cleanliness, these compounds can be used many times over.

The balance of the equipment consisted of several large glass racks, fourteen feet long and eight feet high—large enough to hold as big a piece of glass as ever came into the shop. The glass was placed on these large racks, coated, pounced, cut and sandblasted without being removed until it was ready for delivery. Coasters on these racks enabled us to move them about at will. Several smaller glass racks, such as can be found in any glass shop, two cutting tables, several long, low tables to place material on for coating, two large work tables, an easel, a wash rack, for all glass had to be absolutely clean when it left the shop, and a drying rack completed the equipment. Ample light and plenty of space helped to produce fine work and lessen the risk of accidents.

As the business increased, and due to the demand for sandblasted mirrors, a mirroring department was added that proved very profitable. The first sandblasted mirror contract secured more than paid for the added cost of equipment and labor in this department. A concrete-top silvering table and the necessary chemicals were all that was required. A silvering formula was procured that was quick and positive in action and was permanent on the glass. Its results compare most favorably with the best mirrors obtainable. The table was not heated. The formula used for silvering is known as a "sold" formula. Precipitation took place within five minutes after pouring. The making of mirrors led into other fields and many novelties in sandblasted and silvered glass were the results.

A demand for stained or colored sandblasted glass brought about the addition of a color department. More ex-

periment, more losses of temper and peace of mind; but satisfactory results in that field were finally obtained. There are a good many transparent dye colors on the market that can be applied to sandblasted glass; and although none of them will retain their permanency in sunlight, most of them will keep enough color to warrant their use. The application of color to sandblasted glass is difficult. But experiment and practice will tell the story. Application is by hand and also with a small artist's spray-gun. Both methods are effective, under varied conditions.

BUILDING UP THE BUSINESS

As we progressed, new markets opened up. We sold direct to the new home builders, the contractors and architects. The development of novelties warranted our soliciting shops and stores and advertising agencies. Every new product that came into the market was solicited for sandblasted signs. Lighting fixture houses were canvassed. Garages and bus companies and concerns having large fleets of trucks and cars were solicited for paint removal. It seemed there was no end to the possibilities of sandblasting and we do not believe there is. Every day someone suggested a new idea or thought to us that we managed to turn into a use for sandblasting.

In stores, buildings and homes we installed sandblasted glass for use in transoms, show windows, valences, bank counter screens, lighting fixtures, office partitions, show case tops, mirrors, clock dials, entrance doors, skylights, ceiling and wall lighting panels, desk tops, bathroom walls, bathroom windows, shower doors, studio windows, table tops, false windows. We have made remarkable portraits in glass. We have decorated and sold quantities of ash trays, smokers sets, glass plates, coats of arms, vases, bottles, drinking glasses, trays, desk sets.

All kinds of wood have been effectively treated with sandblast, with designs or to acquire a special finish, or a weather-worn or antique look.

Doors in homes and apartment houses, sandblasted then stained or colored are particularly effective. Other applications were wood mouldings, beam ceilings, lobby and wall panels, shelves, mantels, and other places where wood was used for decorative or finish purposes.

The new polished metals lent themselves well to sandblast treatment and made smart-looking signs.

Sandblasting is interesting. It is fascinating. Plenty of trouble goes with it, too. But after all, those troubles seemed small enough the day after they happened and only succeeded in adding a little more knowledge and experience to what we had already learned.

Echo from Glass Division Meeting

Wednesday noon after lunch moving pictures were shown of the Bridgeville Tube Plant of the General Electric Company, and also of the summer meeting of the Glass Division. Paul Geer of the Amsler-Morton Company who took the pictures was responsible for this courtesy.

GLASS CONSULTANTS

THE SHARP-SCHURTZ COMPANY
CHEMISTS AND CONSULTING ENGINEERS
FOR THE GLASS INDUSTRY
LANCASTER, OHIO U. S. A.

BAILEY & SHARP CO.
INCORPORATED
CONSULTING ENGINEERS
GLASS TECHNOLOGISTS
CABLE ADDRESS "SHARPGLASS"
HAMBURG, N. Y. U. S. A.

PHONE, BUTLER 43510
F. W. PRESTON
CIVIL ENGINEER AND GLASS TECHNOLOGIST
BUTLER, PA.

DESIGNERS and CONSTRUCTORS OF THE BETTER GLASS PRODUCING UNITS
Toledo Engineering Co., Inc.
983 FRONT ST. TOLEDO, OHIO

Current Prices of Glass-Making Materials

February 23, 1933

Quotations furnished by various producers, manufacturers and dealers.

Acid		Carlots	Less Carlots
Citric (dom.)	lb	..	.29
Hydrochloric (HCl) 20° tanks, per 100 lb		..	1.10
Hydrofluoric (HF) 60% (lead carboy)	lb	..	.13½
52% and 48%	lb	.10	10-.11½
Nitric (HNO_3) 38° carboy ext. Per 100 lb		5.50	..
Sulphuric (H_2SO_4) 66° tank cars	ton	15.50	..
Tartaric	lb	..	.20
Alcohol, denatured	gal	..	..
Aluminum hydrate ($Al(OH)_3$)	lb	.04-.04½	.05½-.06
Aluminum oxide (Al_2O_3)	lb	.07	.09
Ammonium bifluoride (NH_4) FHF	lb	..	.15½
Ammonia water (NH_4OH) 26° drums	lb		
Antimony, metallic (Sb)	lb	.02½	.02¾
Antimony oxide (Sb_2O_3)	lb	..	.09½
Antimony sulphide (Sb_2S_3)	lb	..	.08½
Arsenic trioxide (As_2O_3) (dense white). 99%	lb	.. .04	.14 .04½
Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%, 99% through 200 mesh	ton	47.00	..
90% through 100 mesh	ton	44.00	..
Barium hydrate ($Ba(OH)_2$)	lb	..	.05¼
Barium mixture, glassmaker's, f.o.b. St. Louis	ton	25.00	..
Barium nitrate ($Ba(NO_3)_2$)	lb	..	.07¼
Barium selenite ($BaSeO_3$)	lb	..	..
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots bulk, f.o.b. shipping point,	ton	15.00-16.00	18.00
Bone ash	carlots, lb	.06	.06
Borax ($Na_2B_4O_7 10H_2O$)	lb	..	..
Granulated	In bags, lb.	.02	.02¼-.02½
Powdered	In bags, lb.	.02¼	.02½-.02¾
Boric acid (H_3BO_3)	In bags, lb.	.04¼	.04½-.04¾
Cadmium sulphide (CdS)—			
Red	lb	..	.60-.75
Orange	lb	..	.55-.65
Yellow	lb		1.30-1.50
Chromium oxide (Cr_2O_3)	lb	.18½	.19
Cobalt oxide (Co_3O_4)			
In bbls.	lb	..	1.15-1.25
In 10 lb. tins	lb	.	1.35
Copper oxide			
Red (Cu_2O)	lb	..	.25
Black (CuO)	lb	..	.17-.19
Black prepared	lb	..	.22
Cryolite ($Na_3Al F_6$) Natural Greenland Kryolith)	lb	.08½	.09
Synthetic (Artificial)	lb	..	.09½
Epsom salts ($MgSO_4$) (Imported) Per 100 lb		..	1.15-1.20
Feldspar—			
100 mesh	ton	11.50-17.50	12.00-18.00
80 mesh	ton	11.00-11.50	13.00
40 mesh	ton	10.75-11.00	12.00
20 mesh	ton	9.50-11.00	..
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%)			
Bulk, carloads, f.o.b. mines	ton	30.00	..
In bags or barrels	ton	34.00	39.00
Imported	ton	30.00-31.00	33.00-37.00
Formaldehyde	lb	..	.07
Graphite (C)	lb	..	.04-.07
Iron oxide—			
Red (Fe_2O_3)	lb	..	.0425
Black (FeO)	lb	.04½	..
Kaolin (f.o.b. mine)	ton	8.00-9.00	..
English, lump, f.o.b. New York	ton	14.50-25.00	24.50-30.00

Kryolith (see Cryolite)		Carlots	Less Carlots
Lead chromate ($PbCrO_4$)	lb	..	.30
Lead oxide (Pb_3O_4) (red lead)	lb	.055	.06½
Litharge (PbO)	lb	.045	.05½
Lime—			
Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	5.50	..
Burnt (CaO) ground, in bulk	ton	4.00	..
Burnt, ground, in paper sacks	ton	6.00	..
Burnt, ground, in 280 lb. bbls.	Per bbl.	2.15	..
Limestone ($CaCO_3$)		1.50-2.50	..
Magnesia (MgO)—			
Calcined, heavy (in bbls.)	lb	.06	07
" light (in bbls.)	lb	..	.22
" extra light (in bbls.)	lb	..	.27
Magnesium carbonate ($MgCO_3$)	lb	.06	.10
Manganese 85% (MnO_2)	lb	.03	.03
Nickel oxide (Ni_2O_3), black— for nickel content	lb	..	.35
Nickel monoxide (NiO), green— for nickel content	lb	..	.35
Plaster of Paris, bags	ton	21.00	23.00-29.00
Potassium bichromate ($K_2Cr_2O_7$)—			
Crystals	lb	.09	.09¼
Ground	lb	11	12
Potassium carbonate—94-96%	lb	.0555	.0555
Calcined (K_2CO_3) 96-98%	lb	.06¼	.07
Hydrated 80-85%	lb	.05¾	.06¼
Potassium chromate (K_2CrO_4)	lb	..	.25
Potassium hydrate (KOH) (caustic potash)	lb	07¼	.08
Potassium nitrate (KNO_3) (gran.)	lb	..	06-.06¼
Potassium permanganate ($KMnO_4$)	lb	.16½	.17
Powdered blue	lb	..	.28-.30
Rochelle salts, bbls.	lb	..	.11½
Rouge	lb	..	..
Rutile (TiO_2) powdered, 95%	lb	.15-.20	.20-.25
Salt cake, glassmakers (Na_2SO_4)	ton	18.00	..
Selenium (Se)	lb	..	1.70
Silver nitrate ($AgNO_3$)	(100 oz.) per oz	..	.20
Soda ash (Na_2CO_3) dense, 58%—			
Bulk, on contract	Flat per 100 lb	1.05	..
In barrels	Per 100 lb.	1.38	1.90-2.13
In bags	Per 100 lb.	1.17½	1.72½-1.92½
Spot orders .. .025 per 100 lbs. higher		..	..
Sodium bichromate ($Na_2Cr_2O_7$)	lb	.07	.07½
Sodium hydrate (NaOH) (caustic soda) Solid	Per 100 lt	2.50	..
Sodium nitrate ($NaNO_3$)—			
Refined (gran.) in bbls.	lb	..	3.62
95 per cent.	Per 100 lb	1.195-1.295	1.145-1.345
Sodium selenite (Na_2SeO_3)	lb	..	2.00
Sodium fluosilicate (Na_2SiF_6)	lb	.05½	.06
Sodium uranate (Na_2UO_4) Yellow or Orange	lb	..	1.50-1.55
Sulphur (S)—			
Flowers, in bbls.	Per 100 lb	3.46	3.80-4.00
Flowers, in bags	Per 100 lb	3.10	3.45-3.65
Flour, heavy in bbls.	Per 100 lb	2.85	3.20-3.40
Tin chloride ($SnCl_2$) (crystals)	lb	.37½	.39
Tin oxide (SnO_2) in bbls.	lb	.28	.29½
Uranium oxide (UO_3) (black, 96% U_3O_8) 100 lb. lots. Black	lb	..	2.75
Yellow	lb	..	1.50
Zinc oxide (ZnO)	lb	08½	12
American process. Bags	lb	.05¾	.06
Zircon			
Granular (Milled .005-.02c higher)		07	07½-.08
Crude, Gran. (Milled .005-.02c higher)		03½	04-.05